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METHOD AND DEVICE FOR MONITORING BLIND SPOTS OF A MOTOR VEHICLE

The present invention relates to a method and a device for monitoring blind spots of a motor vehicle according to the definition of the species in Claim 1 and Claim 10.

A driver of a vehicle is able directly to examine the region around his vehicle through the vehicle's windows, and indirectly through the vehicle's rear view mirrors. In this context, the driver is able to examine through the vehicle's windows predominantly the region in front of the vehicle and at the sides of the vehicle, whereas the region behind the vehicle may be examined using the vehicle's inside rearview mirror, and the regions laterally behind the vehicle may be examined using one or more of the vehicle's outer rearview mirrors.

Because of the restricted field of view of the driver and the geometrical relationships in a vehicle, that is, for example, because of posts between the vehicle's windows that hinder vision, it is generally not possible for the driver of the vehicle to examine all the regions around a vehicle without turning around or turning the head. Directly behind and in front of the vehicle there are regions that the driver is not able to examine. Similarly, there are regions at the side of the vehicle that the driver is not able to examine without a considerable change in the field of vision by turning his head. These difficult-to-examine regions at the sides of the vehicle are designated as blind spot regions of the vehicle, this region varying depending on the size and sitting position of the driver as well as with the kind and the setting of the outside mirrors.

From EP 1 026 522 A2, a system is known for monitoring a region at the side of a vehicle in a dynamic traffic environment. In this context, the system has an IR transmitting unit and an IR receiving unit which are situated at the side of the vehicle. These IR transmitting and receiving units define a lateral region that is to be monitored, an evaluating unit establishing whether an object is located in the monitoring region. The presence of an object in the monitored region is notified to the driver via a suitable display unit. What is disadvantageous in the known system is that the driver has also pointed out to him objects which are meaningless for the guidance of his vehicle.

The present invention is therefore based on the object of creating a method and a device for monitoring blind spots of a motor vehicle, the driver only receiving a warning if the object detected in the blind spot has a meaning with respect to the guidance of the vehicle.

The object is attained by the features of the method according to Claim 1 and those of the device according to Claim 10. Preferred embodiments of the present invention constitute the subject matter of the dependent claims.

The method, according to the present invention, for monitoring the blind spot at the side of a motor vehicle, that activates a warning function for giving off a warning to the driver if an object is located in a predefined warning range, has the following steps:

a) determining the relative speed v_{rel} between object and motor vehicle, determining the travel direction of the object relative to the motor vehicle and determining the position of the object relative to the motor vehicle within a predefined sensor range.

b) giving out a warning to the driver if the travel direction of the object corresponds to that of the motor vehicle, the relative speed v_{rel} between the object and the vehicle lies within a predetermined range, defined by a lower range boundary v_u and an upper range boundary v_o, the predetermined range of the relative speed including zero, and the position of the object (F2) lying within the warning range.

In this context, the relative speed is with reference to the motor vehicle, in other words, if the relative speed is greater than zero, the object moves faster than the vehicle, and if the relative speed is less than zero, the object is slower than the vehicle, or two-way traffic is involved. Objects may be, for example, pedestrians, vehicles, bicycles, motorcycles, trucks and buses. Furthermore, the travel direction of the object relative to the motor vehicle is defined by the direction of the roadway on which the object is moving relative to the vehicle. In other words, with respect to the motor vehicle, an object is able to have only one of two travel directions, either it moves in the same travel direction as the vehicle or it moves in the opposite travel direction. In the latter case, then, two-way traffic is involved. As a result, an object that has the relative speed of zero with respect to the vehicle, and changes from an outer lane to a lane adjacent to the vehicle, has the same travel direction as the vehicle, although, with respect to the relative speed, it moves in a perpendicular direction towards the vehicle. Furthermore, the sensor range is predefined by the range of the sensor at which it detects objects, and the warning range is the range within which a warning is given off to the driver, that is, the blind spot region. In this context, the warning range is a part of the sensor range.

Preferably, a warning is also generated at relative speeds greater than the positive upper range boundary v_o, i.e. in this

preferred specific embodiment a warning is generated in response to all positive relative speeds, if the additional, above-named conditions are satisfied.

In particular, the predetermined range is defined by the interval of the relative speeds of -30 km/h to +100 km/h, preferably -15 km/h to +50 km/h, and especially -5 km/h to +30 km/h. This has the background that an object approaching at high speed covers a greater path per unit of time, and consequently has to be monitored already at a greater distance. The present invention thus ensures that a driving situation or a warning situation is not only judged based on the fact as to whether an object is located in a static warning range or at a distance or a static warning range or distance that depends on a speed or a driving parameter, but rather, the individual characteristics of the approaching object (such as the speed, the angle (see Fig. 8)) may be incorporated in the judgment, depending on the situation. For the warning function, therefore, for giving out a warning, the distance and the relative speed as well as possibly, in addition, the angular information (see above) are relevant for each recorded object.

In an additional preferred specific embodiment, the range boundaries are a function of the speed of the motor vehicle, in other words, at a low speed of the vehicle, the range boundaries are lowered, whereas at a high speed, the range boundaries are shifted to higher relative speeds.

The warning function is preferably independent of the direction of entry of the object into the blind spot, and the direction of exit of the object from the blind spot. Furthermore, the warning function is independent of the background of the object that enters the blind spot, and independent of standing objects, of their alignment and their

background. In one additional preferred specific embodiment driving situations are classified, each classified driving situation including the information as to whether the warning function is activated or not, when an object enters the blind spot region. The method also has the following steps: determining the current driving situation of motor vehicle and object, ascertaining that classified driving situation which corresponds to the current driving situation, and activating the warning function corresponding to the information of the ascertained classified driving situation.

Preferably, the classification takes into account two additional lanes laterally to the lane of the motor vehicle. This measure is usually sufficient.

In particular, the evaluation of whether a warning function is triggered in response to the entry of an object into a blind spot or warning range of the motor vehicle, is carried out at both sides of the vehicle, in other words, both sides of the motor vehicle are monitored, in order for the monitoring to cover swinging-in procedures as well as passing procedures or lane change in general.

Because an angle is recorded or calculated as an input variable for the warning function in the driving plane of the motor vehicle, which results essentially from the driving direction of the motor vehicle (F1) and the straight line constructed between a sensor device for monitoring a warning range and the object, additional advantageous insights may be obtained for judging the driving situation. If an object is recorded in the warning range (e.g. radial distance undershoots warning threshold), using the additional information on the angle described, a statement may be made as to whether the object is located in an adjacent lane or in a third lane that may be present. If the object is in a third

lane, no warning is required, since swinging out into the middle lane is possible without danger.

A device according to the present invention for carrying out the method explained above includes a sensor device for monitoring a blind spot, the sensor device determining the direction of motion of an object relative to the motor vehicle, the relative speed between the object and the motor vehicle, as well as the position of the object relative to the vehicle, a control unit for valuing the data ascertained, and a warning device for giving out a warning signal to the driver of the motor vehicle as a function of the valuing of the data. The position of the detected object relative to the vehicle is preferably determined by measuring the radial distance from the vehicle and measuring the angle at which the object is approaching.

In particular, the control device includes a memory for storing classified driving conditions and a comparator for comparing a current driving condition ascertained by the control unit from the data of the sensor device to the classified driving conditions.

The sensor device may be situated in a side mirror, an outer mirror, the rear bumper or a rear light of the motor vehicle.

A preferred embodiment of the present invention is explained below on the basis of the schematic drawings. The figures show:

Fig. 1	a definition of the blind spot of a motor vehicle,
Fig. 2a - 2c	warning situations in response to selected driving situation,

Fig. 3a - 3c situations without activation of the warning function,

Fig. 4a - 4c a schematic representation of the preferred speed range,

Fig. 5a – 5d possible entry directions and exit directions into and out of a blind spot for vehicles in the same driving direction and for two-way traffic,

Fig. 6a - 6c examples of classified driving situations having triggering of a warning signal,

Fig. 7a - 7c examples of classified driving situations without triggering of a warning signal,

Fig. 8 construction in principle of a device for monitoring blind spots and

Fig. 9 possible definition of an angle between the motor vehicle and an object

Fig. 1 shows a schematic representation of the so-called blind spots on each side of a motor vehicle. What is shown is a motor vehicle F1 which is traveling from right to left in the drawing, in the middle lane S2 of a roadway FB having three lanes S1, S2, S3. Both on the driver's side and on the passenger's side, in each case a rectangular region W1, W2 is shown, having edges a, b which define, for example, a rectangle of ca. 5 m x 5 m. These approximate regions W1, W2 are defined below as blind spot regions or warning regions, which are not able to be examined by the driver in the outside mirrors. The regions depend on the size and the sitting

position of the driver, as well as on the type and the setting of the outside mirrors, as well as on the construction of the vehicle itself. Furthermore, the size of the blind spot regions depends on the driving situation, such as the speed.

In the following Figures 2a-c, 3a-c, 5a-d, 6a-c, 7a-c and 8a-c, that vehicle into whose driver-side blind spot an object is entering, is designated as vehicle F1, and the object is specified by an additional vehicle F2, which is denoted as the object vehicle. The direction of motion of vehicle F1, whose blind spot is being considered, is from right to left in the plane of the drawings.

Fig. 2a shows a passing procedure, in which two vehicles F1 and F2 have the same travel direction FR, and vehicle F1 is being slowly passed by faster object vehicle F2. Because of the penetration of object vehicle F2 into the driver's side blind spot region W1 of vehicle F1, a warning is triggered.

Fig. 2b shows a situation comparable to that in Fig. 2a, in which object vehicle F2, located in blind spot region W1 of vehicle F1, has the same speed as vehicle F1. A warning to the driver of vehicle F1 takes place.

Fig. 2c shows a situation in which object vehicle F2 slowly drops back compared to vehicle F1, which is shown by the arrow directed rearward, and wanders through the blind spot of vehicle F1. A warning to the driver of vehicle F1 takes place. Travel direction FR of the two vehicles F1, F2 is identical here too.

Additional situations, such as the ones shown in Figures 3a to 3c, in which a warning function is triggered by the penetration of an object into a blind spot of a vehicle, may

be defined both for the driver's side and, analogously, for the passenger's side.

Fig. 3a shows a situation in which object vehicle F2 enters the driver's side blind spot W1 of vehicle F1 as two-way traffic. In principle, in the case of two-way traffic no warning is given. The perception of an object as constituting two-way traffic takes place, for instance, by the detection of a negative relative speed V_{rel} and, judging by the number, high relative speed V_{rel} ($V_{rel} \leq v_u$, see Fig. 4).

Fig. 3b shows the passing of vehicle F1 of standing vehicle F2. Here, too, there is no warning in response to an entry of a standing vehicle into the blind spot region of another vehicle. The perception of an object as a standing object takes place, for example, by the detected relative speed V_{rel}, which is equal to the characteristic speed V_{F1} of vehicle F1.

Finally, Fig. 3c shows a situation in which both vehicles move in the same travel direction FR, and object vehicle F2 drops back rapidly with respect to vehicle F1 that is moving in the same direction, which is shown by the bigger directional arrow shown pointing to the right in the drawing. In other words, object vehicle F2 runs through blind spot region W1 of vehicle F1 from front to back, and the situation may be described as a passing procedure of vehicle 1. No warning takes place in this situation. Relative speed V_{rel} of object vehicle F2, detected by vehicle F1, is negative in this context ($V_{rel} \leq V_u$, Fig. 4). However, inasmuch as the object vehicle drops back slowly ($V_u \leq V_{rel} \leq 0$, Fig. 4) no warning takes place.

Furthermore, no warning takes place if the blind spot region of a vehicle is empty independently of the background (not shown).

Fig. 4 shows in an illustrated representation the ranges of relative speeds V_{rel} in which, in response to entry of an object into the blind spot region of a vehicle, a warning takes place or not. In this context, relative speed v_{rel} is referred to the vehicle, so as to arrive at a correct sign definition. In the case of relative speeds lower than a lower boundary v_u between the vehicle and an object, no warning is triggered, in the case of relative speeds V_{rel} within a range between the lower boundary v_u and an upper boundary v_o, this range including relative speed zero, a warning is triggered, and in the case of relative speeds greater than upper boundary v_o, the triggering of a warning is optional. The range boundaries named may be functions of characteristic speed V_{F1} and of driving parameters (e.g. acceleration procedure, highway travel and expressway travel) of vehicle F1.

Figures 5a-5d show possible entry and exit directions in a blind spot of a vehicle for vehicles going in the same travel direction FR and for two-way traffic. The concepts used here with respect to the possible entry and exit direction, "right", "left", "front" and "rear" relate to the direction of motion of object vehicle F2.

Fig. 5a shows schematically the 6 essential entry directions, represented by arrows 1.1, 1.2, 1.3, 1.4, 1.5 and 1.6, in which vehicle F2 may enter the driver's side blind spot region W1 of vehicle F1. Also shown are three lanes S1, S2, S3 of a roadway FB. The arrows have the following meaning:

1.1 Entry direction at an angle left forward by change of vehicle F2 from lane S1 to lane S2 (relative speed greater than zero),

1.2 Entry direction forward by vehicle F2 remaining in lane S2 (relative speed greater than zero),

1.3 Entry direction at an angle right forward by change of vehicle F2 from lane S3 to lane S2 (relative speed greater than zero),

1.4 Entry direction to the right by change of vehicle F2 from lane S3 to lane S2 (relative speed equal to zero),

1.5 Entry direction at an angle right rearward by change of vehicle F2 from lane S3 to lane S2 (relative speed less than zero), and

1.6 Entry direction rearward by vehicle F2 remaining in lane S2 (relative speed less than zero).

Fig. 5b shows schematically the 6 essential exit directions, represented by arrows 2.1, 2.2, 2.3, 2.4, 2.5 and 2.6, in which vehicle F2 may exit the driver's side blind spot region W1 of vehicle F1. The arrows have the following meaning:

2.1 Exit direction at an angle right rearward by change of vehicle F2 from lane S2 to lane S1 (relative speed less than zero),

2.2 Exit direction rearward by vehicle F2 remaining in lane S2 (relative speed less than zero),

2.3 Exit direction at an angle right rearward by change of vehicle F2 from lane S2 to lane S3 (relative speed less than zero),

2.4 Exit direction at an angle left by change of vehicle F2 from lane S2 to lane S3 (relative speed equal to zero),

2.5 Exit direction at an angle left forward by change of vehicle F2 from lane S3 to lane S2 (relative speed greater than zero), and

2.6 Exit direction forward by vehicle F2 remaining in lane S2 (relative speed greater than zero).

Fig. 5c shows schematically the 2 essential entry directions, represented by arrows 3.1 and 3.2, in which vehicle F2 may

enter the driver's side blind spot region W1 of vehicle F1 as two-way traffic. The arrows have the following meaning:

3.1 Entry direction at an angle left forward by change of vehicle F2, that is traveling in the opposite direction to the traffic, from lane S3 to lane S2, and

3.2 Entry direction forward by vehicle F2 remaining in lane S2.

Fig. 5d shows schematically the 3 essential exit directions, represented by arrows 4.1, 4.2 and 4.3, in which vehicle F2 may exit the driver's side blind spot region W1 of vehicle F1. The arrows have the following meaning:

4.1 Exit direction at an angle left forward by change of vehicle F2, that is traveling in the opposite direction to the traffic, from lane S2 to lane S1,

4.2 Exit direction forward by vehicle F2, that is traveling in the opposite direction to the traffic, remaining in lane S2, and

4.3 Exit direction at an angle left forward by change of vehicle F2, that is traveling in the opposite direction to the traffic, from lane S2 to lane S3.

The above-named possible entry and exit directions into a blind spot of a vehicle for vehicles going in the same travel direction and for two-way traffic 1.1-1.6, 2.1-2.6, 3.1-3.2 and 4.1-4.3 are used to define the columns of a matrix that describes classified blind spot situations of the driver's side. The rows of the matrix are defined by background objects, such as "no objects", "moving objects", which are subdivided into "passing", "same speed", "dropping back" and "two-way traffic"; and "static objects", such as "pylons", "delineators", "trees", traffic jam", "guardrail" and "tunnel wall". For every possible classified blind spot situation of

the matrix it is stated whether a warning is to be given out in response to the occurrence of the situation.

Figures 6a-6c show three examples of a plurality of possible classified driving situations that have triggering of a warning signal which, in parameterized form, are components of the matrix explained above.

Fig. 6a shows vehicle F1 moving in lane S1, along with object vehicle F2 traveling behind it, which changes in direction 1.1 to lane S2, and thereby arrives in blind spot region W1 of vehicle F1. Since the travel directions of the vehicles are identical, the relative speed is greater than zero (and is located within the predefined range v_u to v_o) and the position P of the object lies within the warning range, a warning is triggered. The object vehicle leaves the blind spot region of vehicle F1 again in direction 2.6.

Fig. 6b shows vehicle F1 moving in lane S1. In lane S2 parallel to it, object vehicle F2 approaches from behind in direction 1.2, and enters blind spot region W1 of vehicle F1. Since the travel directions of the vehicles are identical, the relative speed V_{rel} is greater than zero (and is located within the predefined range v_u to v_o) and the position of the object lies within the warning range, a warning is triggered. The object vehicle leaves the blind spot region of vehicle F1 again in direction 2.6.

Fig. 6c shows vehicle F1 moving in lane S1. Because of a change of object vehicle F2 in direction 1.3 to lane S3, it arrives in blind spot region W1 of vehicle F1. Since the travel directions FR of the vehicles are identical, the relative speed is greater than zero (and is located within the predefined range v_u to v_o) and the object is located within the warning range, a warning is triggered. The object vehicle

leaves the blind spot region of vehicle F1 again in direction 2.6.

Figures 7a - 7c show three examples of a plurality of possible classified driving situations without the triggering of a warning signal.

Fig. 7a shows vehicle F1 having blind spot region W1, which is moving in lane S1 in predefined travel direction (i.e. in the plane of the drawing, from right to left). In lane S2, object vehicle F2 moves in opposite travel direction 3.2, and enters blind spot region W1 of vehicle F1. No warning is triggered. The object vehicle leaves the blind spot region again in direction 4.1, that is, while changing lanes to lane S1. In lane S3, an additional vehicle F3 is moving in opposite travel direction FR to vehicle F1. This vehicle is insignificant for the triggering of a warning, since it does not enter blind spot region W1.

Fig. 7b shows vehicle F1 having blind spot region W1, which is moving in lane S1 in predefined travel direction FR (i.e. in the plane of the drawing, from right to left). In lane S2, object vehicle F2 moves in opposite travel direction, in direction 3.2, and enters blind spot region W1 of vehicle F1. No warning is triggered. The object vehicle leaves the blind spot region again in direction 4.2, i.e. it remains in lane S2. An additional vehicle F3 moves in lane S3 in the opposite travel direction FR to vehicle F1. This vehicle is insignificant for the triggering of a warning, since it does not enter blind spot region W1.

Finally, Fig. 7c shows vehicle F1 having blind spot region W1, which is moving in lane S1 in predefined travel direction FR (i.e. in the plane of the drawing, from right to left). In lane S2, object vehicle F2 moves in opposite travel direction

FR in direction 3.2, and enters blind spot region W1 of vehicle F1. No warning is triggered. The object vehicle leaves the blind spot region again in direction 4.1, i.e. it changes to lane S1. In lane S3 there is a traffic jam having vehicles F3, or there are parking vehicles. These vehicles F3 are insignificant for the triggering of a warning, since they are standing, and, as a result, are treated as background.

Figure 8 shows a construction in principle of a device for monitoring blind spots. A computing device R receives different data about at least one object F2 and/or about one's own driving situation. In this context, the information on object F2 may be made available by a sensor that is not shown. It is also conceivable that information about position P of fixed objects are made available by a memory device (such as a navigation unit). Making available data of a position P for computing device R is shown in Fig. 8 as a broken line arrow. The ascertainment and notification of a travel direction FR may also be made available by a travel direction ascertaining (such as a navigation unit). Optional information branch P is drawn in as a broken line in Fig. 8.

Travel direction determination FRB ascertains travel direction FR from relative speed V_{rel} to a recorded object. In this context, the curve of relative speed over time may also be drawn upon. Thus, travel direction FR of an object F2 that is passing in a lane S2, S3, ($V_{rel} > 0$), which drops back again after the passing procedure ($V_{rel} < 0$), is evaluated as the same travel direction overall.

Relative speed V_{rel}, distance d and angle α between motor vehicle F1 and object F2 (see definition in Fig. 9) are supplied to computing device R. As additional information, characteristic speed V_{F1} and signal are available to computing device R via an operation of the left or right blinker BL, BR.

Additional information on the driving situation, such as acceleration value, the steering angle of motor vehicle F1 may be a part of the data supplied to computing unit R. A warning function warns the driver in an information stage I or in a warning stage W1 according to the following scheme:

If a vehicle is recorded in the warning region, this is signaled to the vehicle operator. An intense or urgent warning takes place as soon as the vehicle operator indicates a lane change in this situation by operating a blinker. In this context, the signaling to the vehicle operator may be performed optically and/or acoustically and/or haptically.

To the extent that additional regions next to motor vehicle F1 are monitored by an additional sensor, additional inputs are correspondingly provided at computing device R.

Fig. 9 shows a possible definition of an angle α, which is recorded as an input variable for the warning function between motor vehicle F1 and an object F2. In this connection, the angle is defined in the travel plane by the travel direction and the straight line that comes about between a sensor device not shown in Fig. 9 and object F2 that is to be monitored. How the straight line, and ultimately angle α are exactly defined, in this context (end point at object F2, in the middle at vehicle beginning or at the object center of gravity, or at an object point having the least clearance distance, etc), is immaterial if the corresponding circumstances find consideration for a certain and reliable warning function in computing device R or in the sensor or other control units.

REFERENCE NUMERAL LIST

F1	vehicle
F2	vehicle
F3	vehicle
FB	roadway
W1	blind spot driver's side
W2	blind spot passenger's side
S1	lane
S2	lane
S3	lane
FR	travel direction
P	position
FRB	travel direction determination
I	information stage
W	warning stage
SP	memory
BL	blinker signal left
BR	blinker signal right
R	computing unit
α	angle
V_{F1}	initial speed
d	distance
a	edge length
b	edge length
1.1-1.6	entry directions
2.1-2.6	exit directions
3.1-3.2	entry directions
4.1-4.3	exit directions
v_{rel}	relative speed
v_o	upper boundary
v_u	lower boundary